Cost of reactive nitrogen release from human activities to the environment in the US

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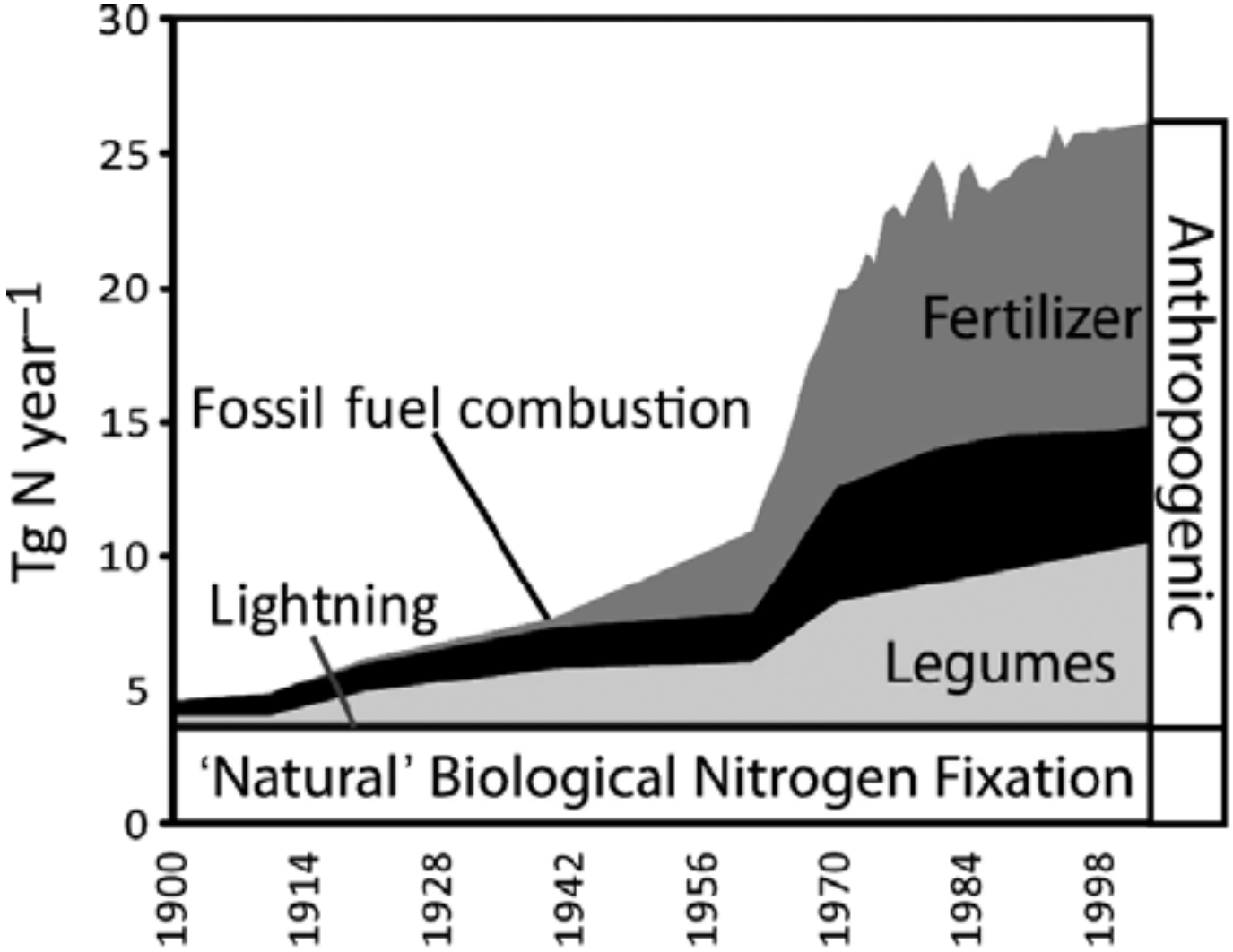
Take home messages

- **First attempt in US to quantify damages associated with reactive N release to the environment.**
- **Opportunity to partner with agricultural community to maximize the benefits of food production yet minimize the loss of N to the environment.**

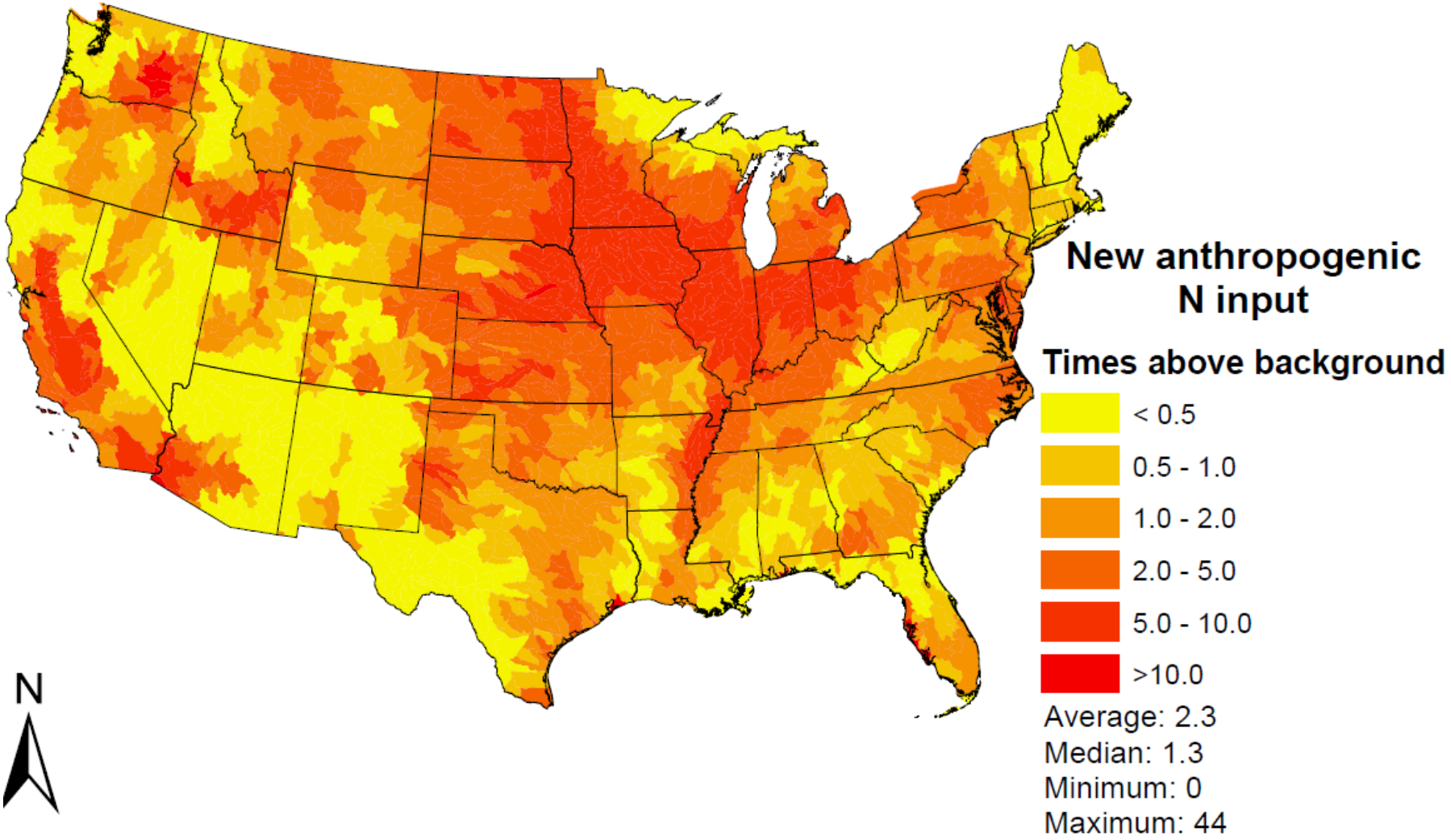
Nitrogen (N) inputs to US

increased 5-fold since 1900



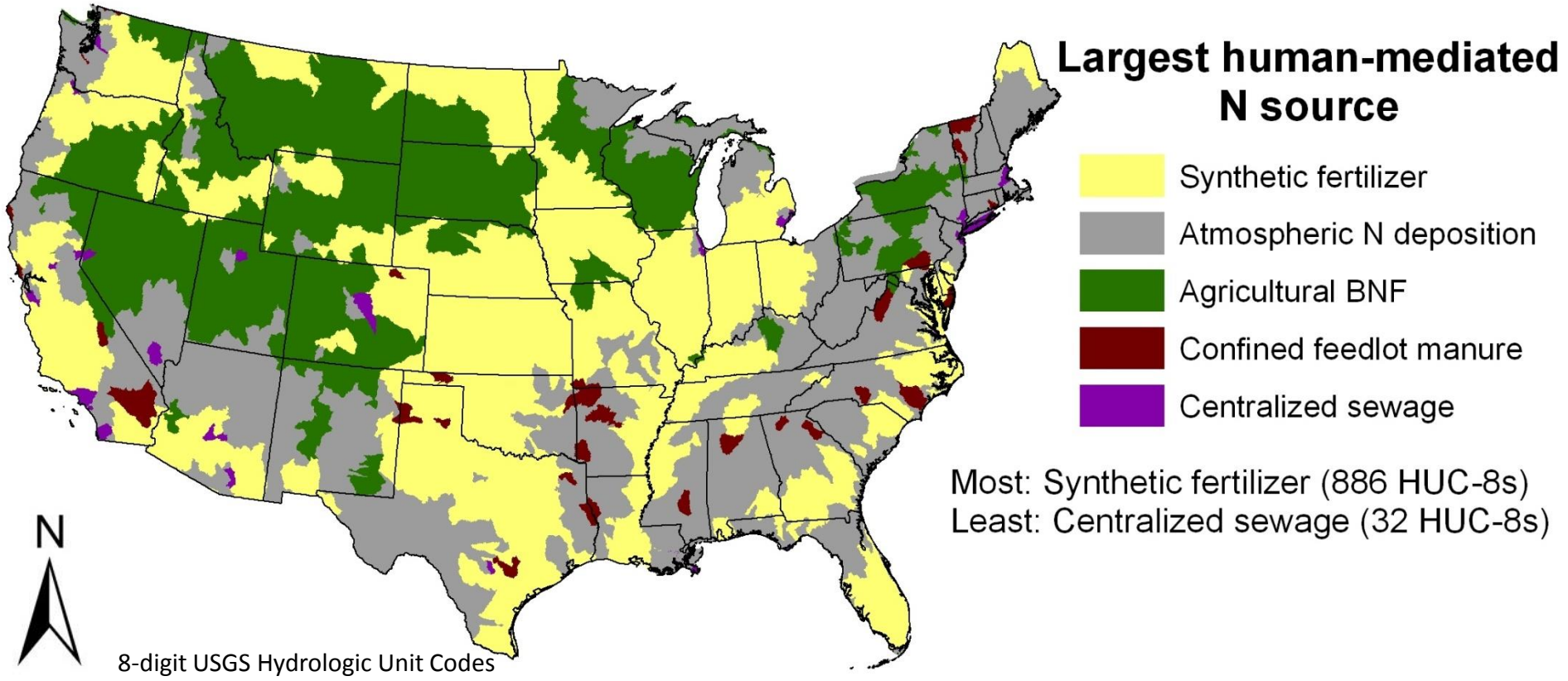
Compton et al. 2011 Ecology Letters

Where are the largest human inputs?



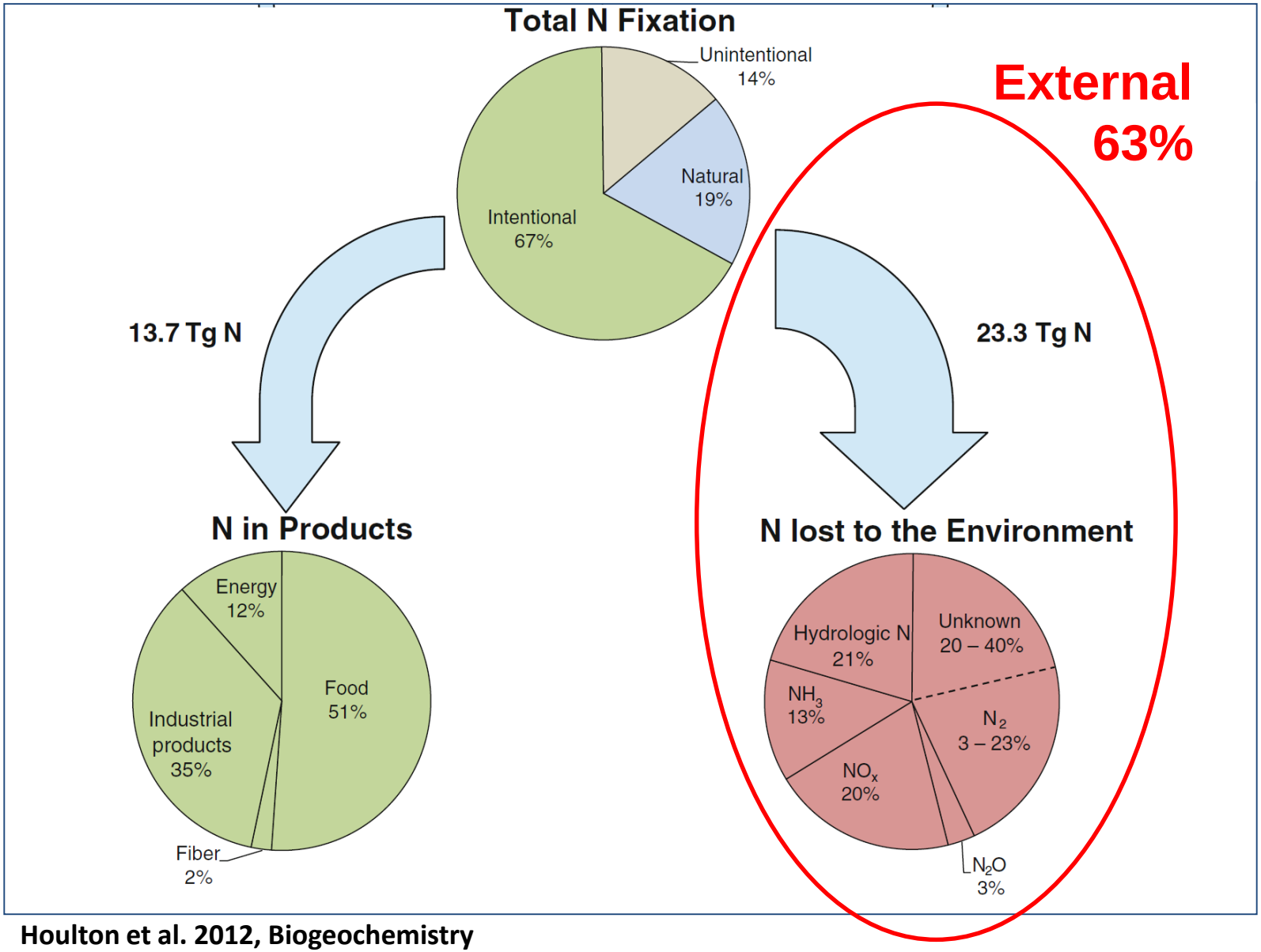
Sobota et al. 2013, FIEE

Dominant Human N Source



Sobota et al., 2013, Frontiers in Ecology and the Environment

What happens to the N inputs?



Houlton et al. 2012, Biogeochemistry

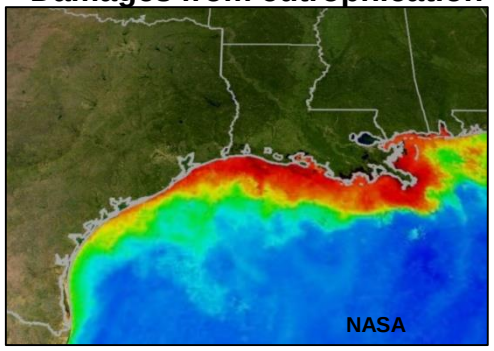
Our approach

- Trace N fate through the cascade
  - Source: Fossil fuel combustion, agriculture, sewage
  - Impacts: human health/social, ecosystems, agriculture, climate
- Combine N flux data with compiled data on N costs
  - $/kg N (Compton et al. 2011; Birch et al. 2011; van Grinsven et al. 2013)

Drinking water contamination

Health effects of smog

Damages from eutrophication

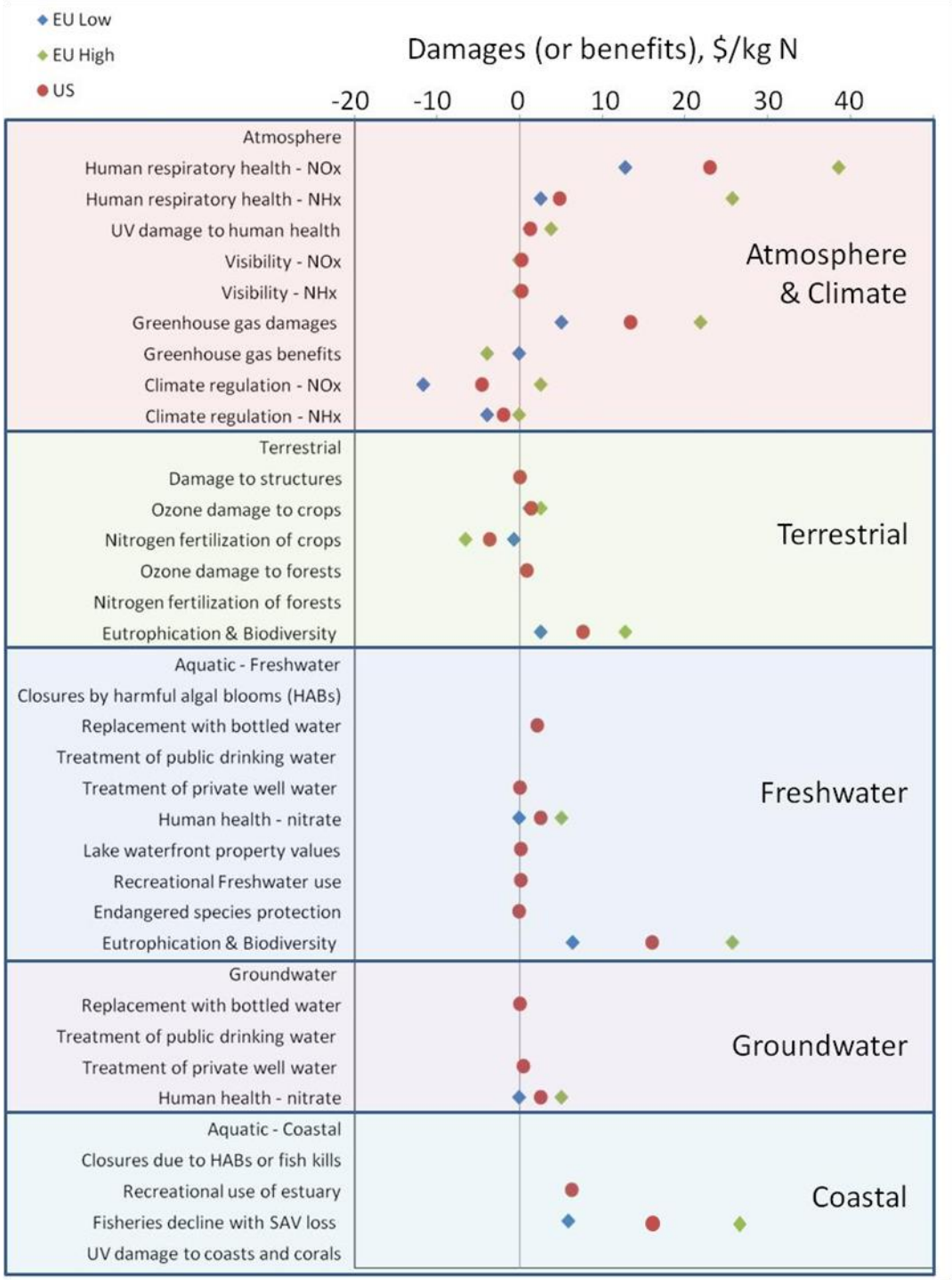


Considerations

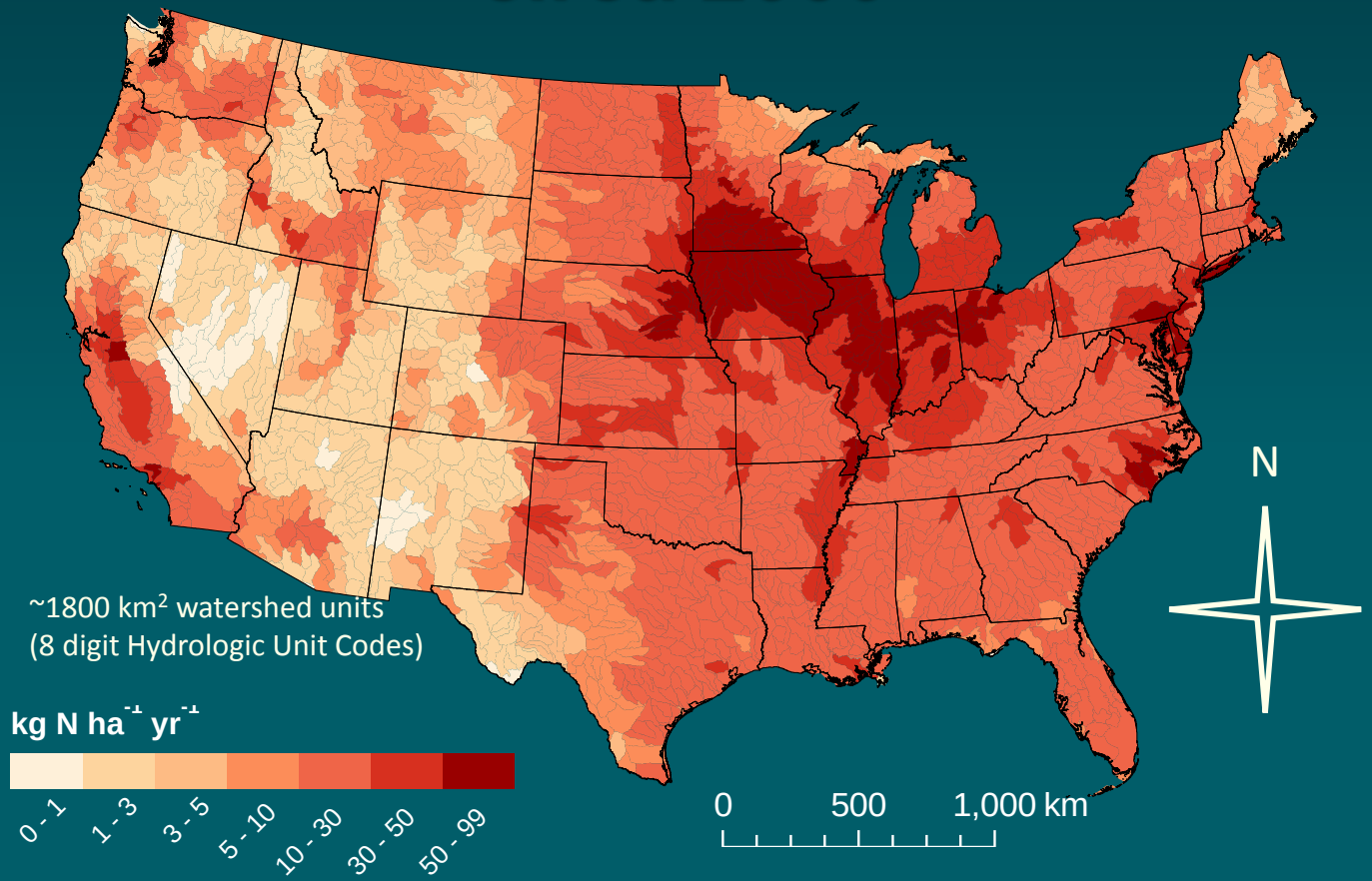
- First attempt to quantify damages from reactive N across the US
- Damage estimates are variable for many effects
- Linear scaling of effects of a kg of N
- These represent potential damages for a particular location

Costs of nitrogen pollution

- For comparison – the low and high values are associated with the EU N Assessment (from Van Grinsven *et al.* 2013 ES&T).

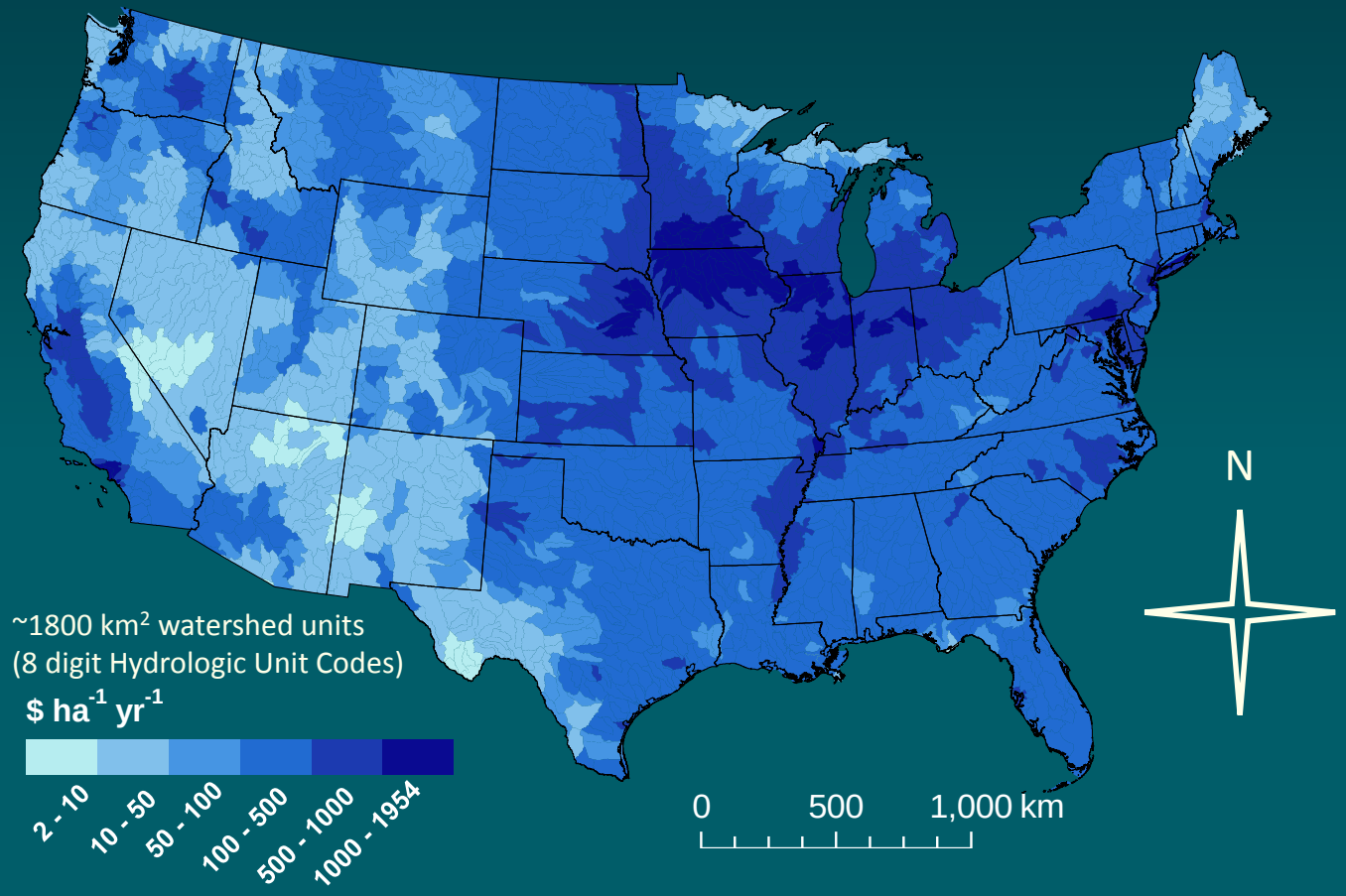


Anthropogenic N leakage to the environment, circa 2000



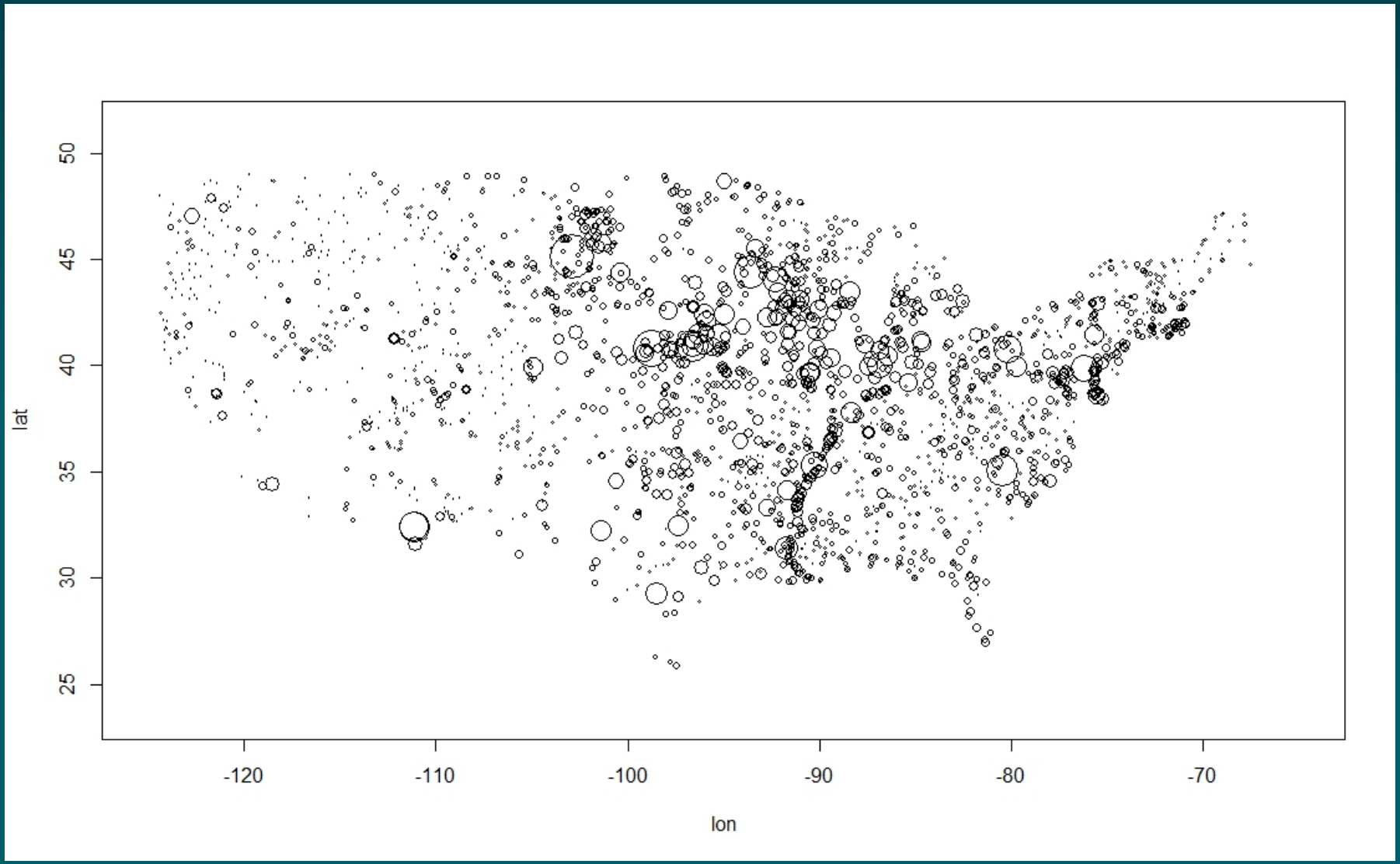
Sobota et al 2015

Freshwater damage costs, circa 2000



Sobota et al. 2015

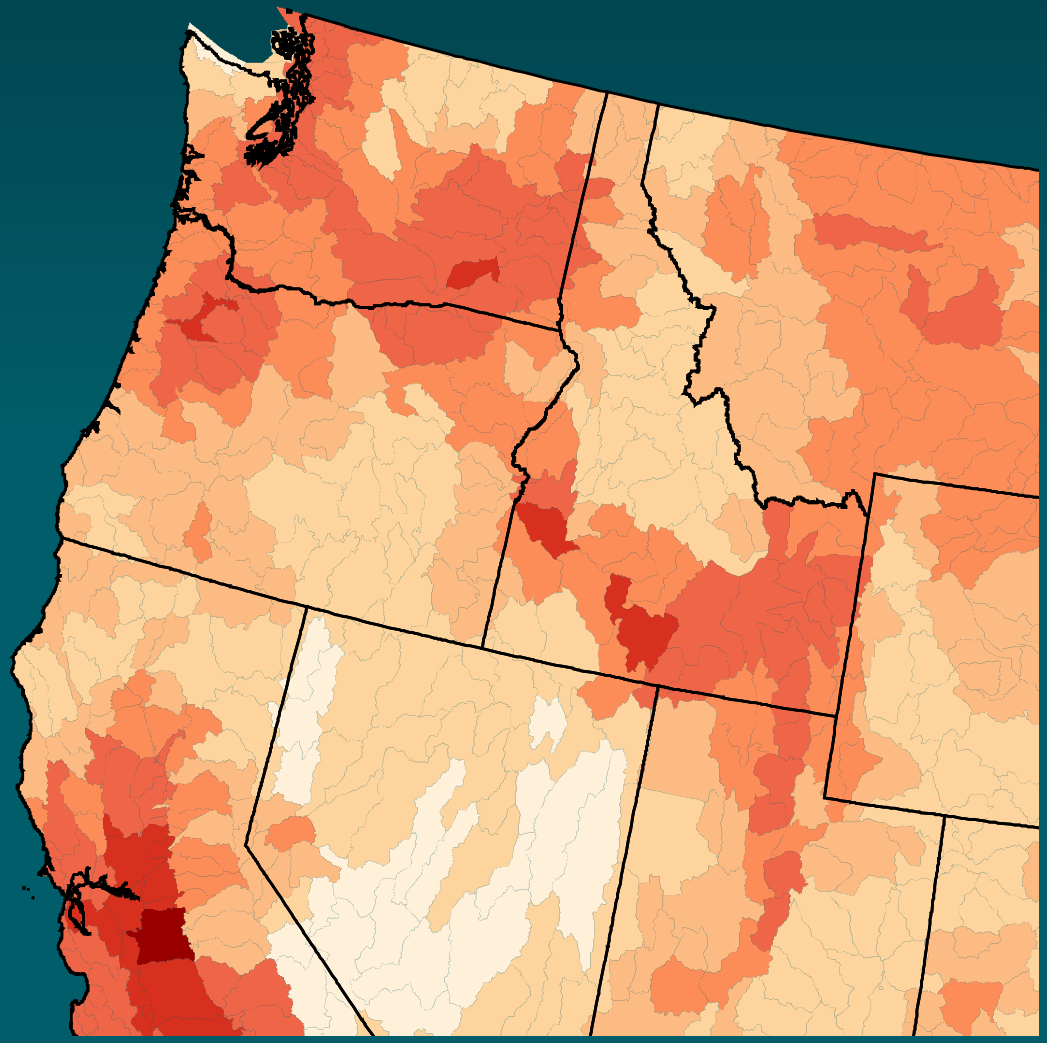
Spatial distribution of [TN] in NARS



Median = 0.604; mean = 1.214 mg N/L

Rebecca Bellmore et al. In prep.

Anthropogenic N leakage to the environment, circa 2000



N

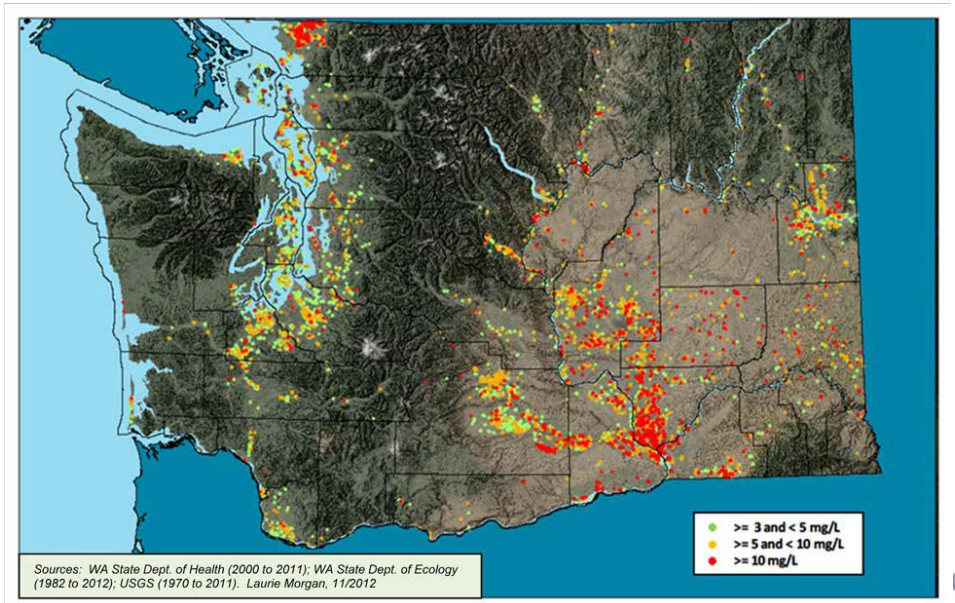
kg N ha^{-1} yr^{-1}

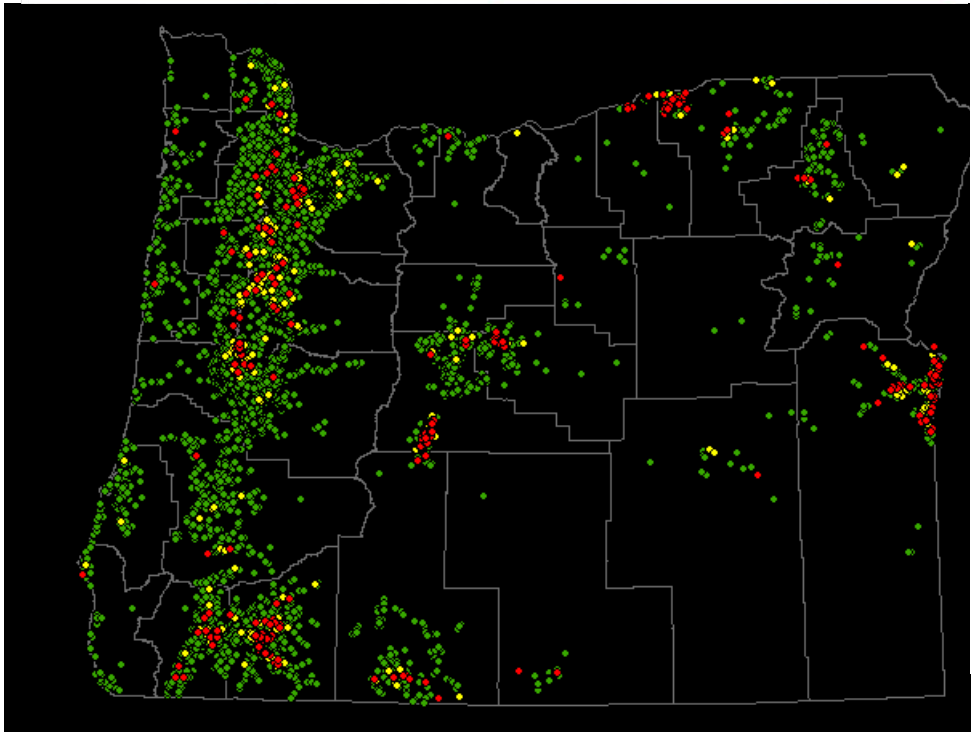
0 - 1 | 1 - 3 | 3 - 5 | 5 - 10 | 10 - 30 | 30 - 50 | 50 - 99

Watershed units
(8 digit Hydrologic Unit Codes)

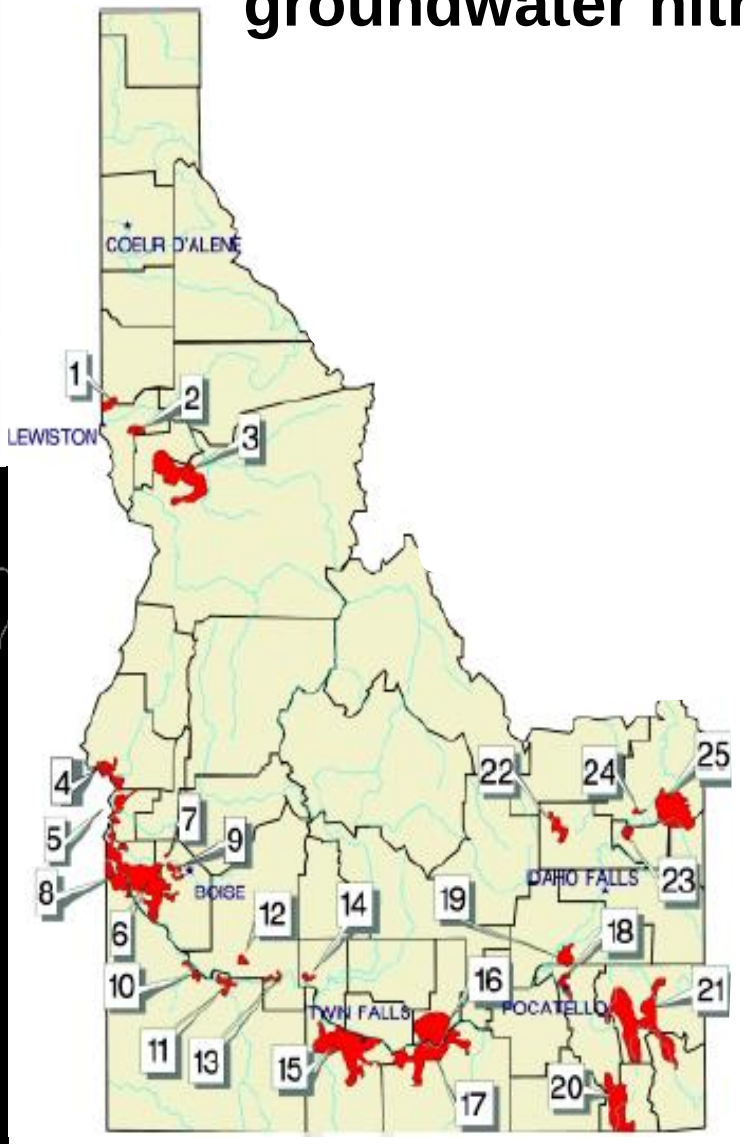
Sobota et al 2015

Leakage reflected in local groundwater nitrate





Real Estate Transaction database
1989-2000, B. Hoppe



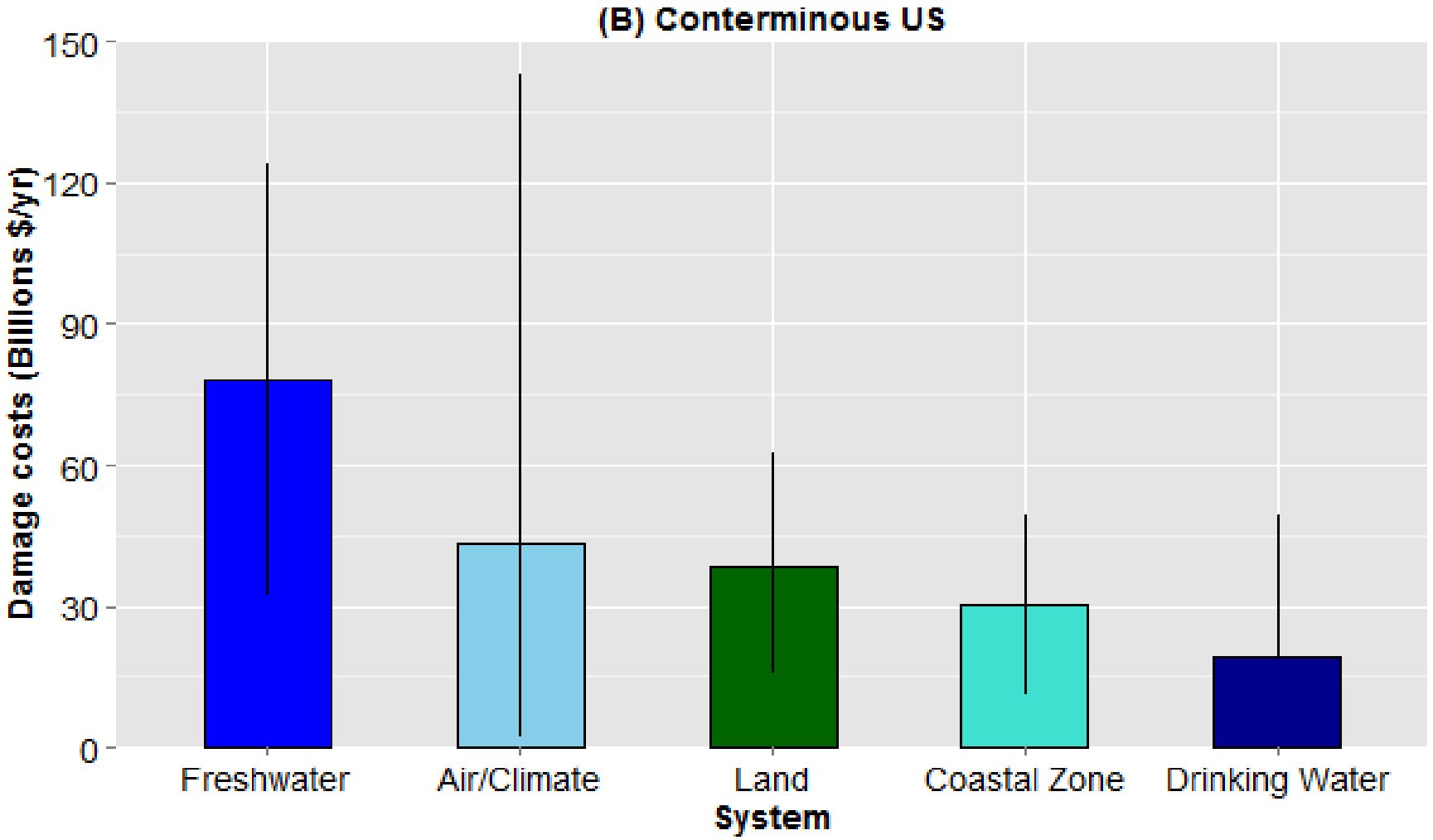
Idaho's Nitrate Areas of Concern

R. L. Mahler and K. E. Keith

Damages from source

Source/Sector	Damage cost (billion USD)
Agriculture	$157.1
Fossil fuel	$50.2
Sewage	$2.3
Total damages from N	**$209.6**
Range	***$81-441***

Damages to endpoints



Other damage estimates

- **Cost of N impacts in the EU27, 2008**
  - $97-625 billion USD (Van Grinsven et al. 2013)
- **Gross annual damages from NO_x and NH_3, 2002**
  - $16 billion USD (Muller and Mendelsohn 2007)
- **Increased mortality associated with NH_3-derived $PM_{2.5}$ from food export, 2006**
  - $36 billion USD (Paulot & Jacob 2013 ES&T)

Summary

- **Human activities have increased N fixation by 5-fold in the US. 65% of N fixation is for agriculture.**
- **71% of N leaked ends up in water resources.**
- **Nitrogen damage costs are substantial - highest costs were in freshwater and coast.**

Summary (cont'd)

- **Many missing costs in our assessment, particularly for algal blooms.**
- **Findings can illustrate the range of benefits of N reductions (i.e. drinking water, air quality, coastal zone) within a place.**
- **Starting point for research connecting nutrients and damages to ecosystem goods and services.**

For more information →

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Also see: EPA SAB Integrated nitrogen committee report 2011
EU Nitrogen Assessment 2011
International Nitrogen Initiative website